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THE REAL CARBON SAVINGS OF WIND

Marginal Greenhouse Gas Emissions Displacement of Wind Power

R Camilla Thomson, Gareth P Harrison and John P Chick

Institute for Energy Systems, School of Engineering, University of Edinburgh

c.thomson@ed.ac.uk

Background & Method

- There is currently no reliable estimate for the reduction in Greenhouse Gas (GHG) emissions attributable to wind power generation.
- Wind is likely to mostly displace marginal carbon-intensive coal- and gas-fired (CCGT) generation (Fig. 1).
- There is, however, an efficiency penalty associated with operating coal and CCGT plant at part load, which will increase their emissions per unit of output energy (Fig. 2).
- This work estimates the true emissions savings of wind power in Great Britain through a marginal analysis of real data from the National Grid.
- The method is based on that developed by Hawkes¹, and examines the relationship between the half-hourly changes in power outputs and GHG emissions to extract the relationship between changing emissions and wind generation (Figs. 3 and 4).
- Part load curves for coal and CCGT plant were derived from Balancing Mechanism data³, with all other values taken from historic generation data aggregated by fuel type.

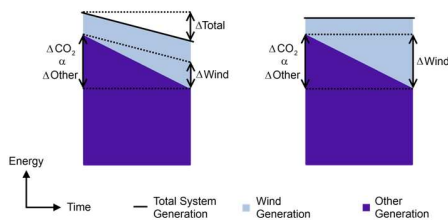


Fig. 3 – Marginal changes in total system generation must be taken into account to isolate the emissions displacement of marginal changes in wind power output.

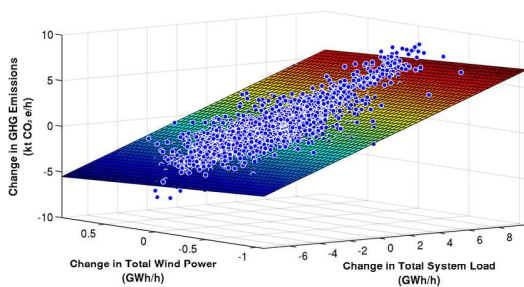


Fig. 4 – A planar fit is applied to data extracted from the National Grid. The marginal emissions displacement of wind power is estimated from the gradient of the resulting line when change in total system load = 0.

Conclusions

- Reliable figures for the actual emissions savings of wind power will support carbon payback calculations and inform policy decisions.
- Wind power is mostly replacing carbon-intensive coal and gas-fired generation, but the efficiency penalties of operating these at part load mean that the GHG emissions savings are not as high as might be expected.
- The actual emissions savings are higher than the value currently used to calculate carbon paybacks, suggesting that current estimates are valid and wind farms really do reduce CO₂ emissions.
- This work does not yet include a reliable model for start-up and shut-down situations, and thus may overestimate the efficiency penalties.

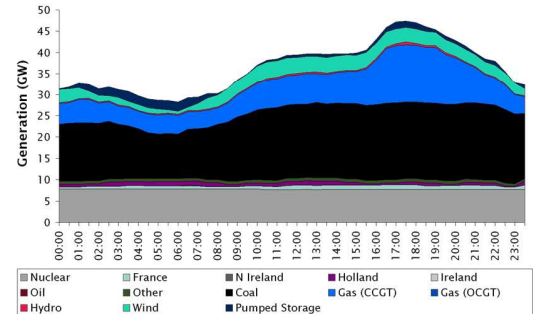


Fig. 1 – Total generation by fuel type, 9th December 2012. Wind power does not replace all forms of generation equally, as nuclear power output remains constant.

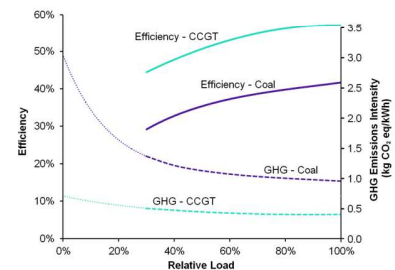


Fig. 2 – Coal and gas-fired power stations operate at a lower efficiency at part load, which increases the GHG emissions intensity of their output power.

Results

- The marginal emissions displacement from November 2008 to June 2013 averaged **0.56 kg CO₂e/kWh**.
- The marginal emissions displacement was found to be significantly higher than emissions factors reported by the UK government (Fig. 5).
- Recent reductions in coal prices have resulted in a decrease in the marginal emissions displacement of wind, as gas-fired plants are providing a higher proportion of marginal generation.

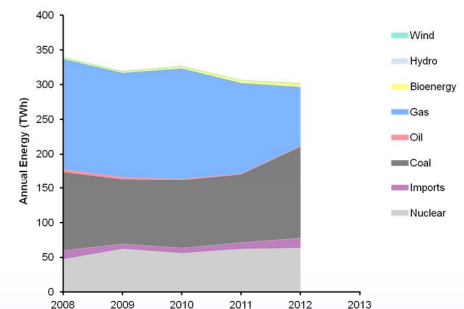
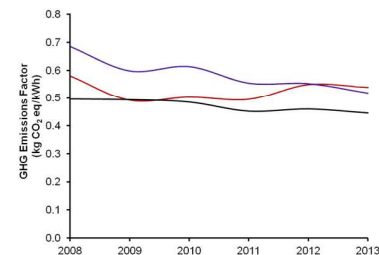


Fig. 5 – The marginal emissions displacement has decreased over time, but remains higher than the reported annual emissions factors. It is likely that some of this reduction is due to a change in the relative prices of coal and gas.